Development of flexible **µECoG** electrode arrays for chronic use in brain cavities.

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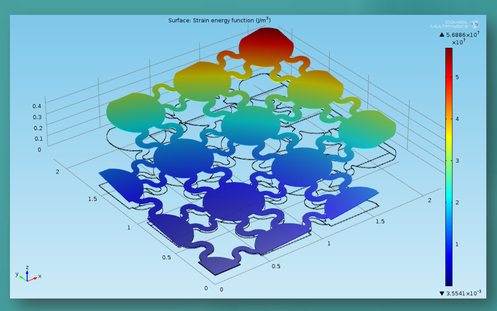
Objective

- Long term local field potential measurements over curved surfaces such as arising in the brain after tumor resection
  - Mechanically flexible
  - Optional resorbable coating for increased stiffness during insertion
  - Coating research for increasing biocompatibility

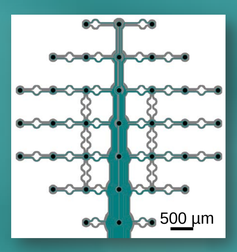
Design

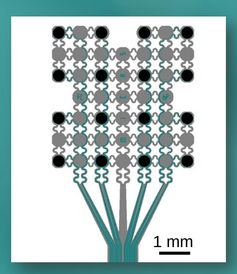
Design in a tree or web shape for high bendability over a 5 mm radius sphere. Compared to an unpatterned sheet, the required bending energy per area was reduced by 95% in FE simulations. The low total thickness of 7 µm (PI version) further adds to the bendability.

The tree-shaped design features 38 100 µm diameter electrodes, the web-shaped design 16 350 µm electrodes. Both cover a 4.5x4.5 mm area.



Bending energy calculated by FE simulating a Lambert projection on a 1 cm diameter sphere.

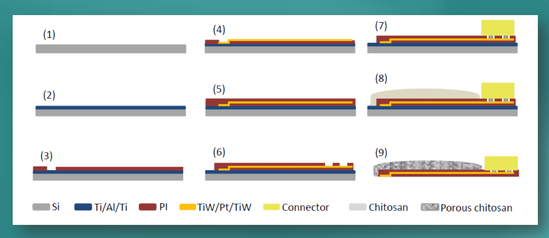




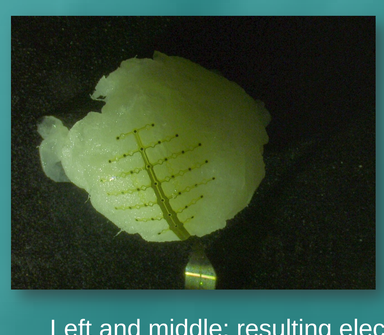
Tree-shaped and web-shaped designs

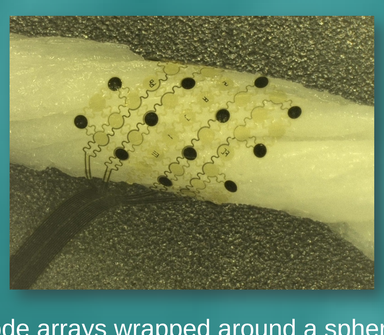
Fabrication

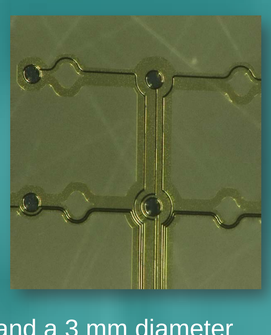
- Polyimide (PI) or Parylene-C isolation
- Sputtered Pt conductors
- Patterning based on LOR10B liftoff resist
- RIE for insulator patterning
- Resorbable porous layer (e.g. chitosan) can be added



For PI, an *improved fabrication process* was introduced. In this process, the curing temperature for the lower PI layer was lowered to 205 °C to increase the remaining reactivity, improving bonding with the upper insulation layer.







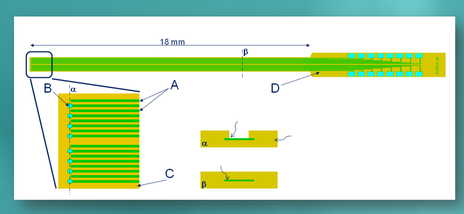
Left and middle: resulting electrode arrays wrapped around a sphere and a 3 mm diameter mock nerve. Right: detail of top of array.

Testing

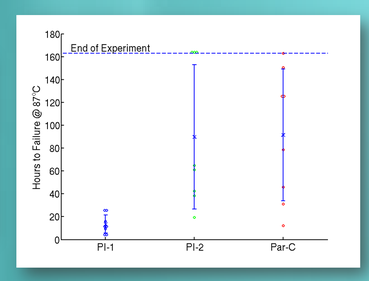
• Insulation lifetime

Accelerated aging tests at 87 °C in PBS show a 7x increase in lifetime of the improved PI process compared to the standard fabrication procedure.

Parylene-C annealed at 200 °C performs similarly.



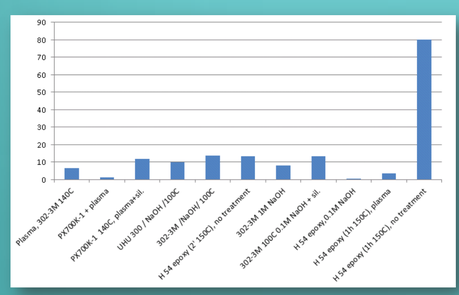
Top and left: test structure. Right under: possible failure mechanisms



Results of accelerated aging test. Channel failure was defined as a drop in DC insulation impedance below 50 MΩ. PI-1: standard fabrication procedure. PI-2: Adapted procedure. Par-C: Parylene-C, annealed at 200 °C.

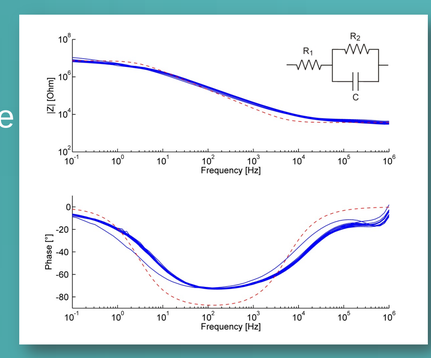
• Connector underfill

12 combinations of underfill material and surface treatment were tested on PI in accelerated aging conditions. H54 epoxy (1h @ 150 °C cure) was found to be superior.



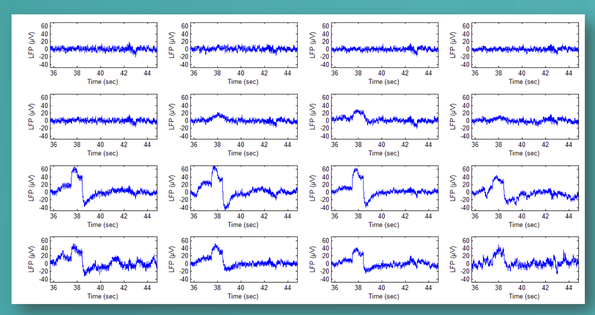
• Impedance

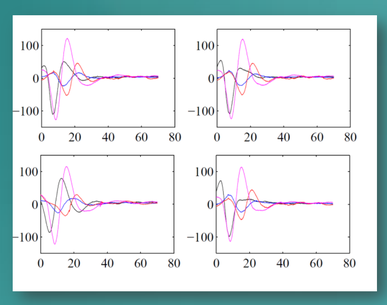
Absolute value and phase of the measured impedance of the 90 µm diameter Pt electrodes of a net shaped electrode array, measured in PBS solution.
The red dashed line displays the fit of the data to the simple equivalent circuit model displayed in the upper right corner, with R1= 7.2 MΩ, R2=3700 Ω and C=7.7 nF.



• In vivo tests

The 4x4 implants were implanted in rats with induced brain damage.
Shown is an example recording on the motor cortex during a ladder walk test. →





← Evoked potential measurement done in motor cortex under general anesthesia, 6 months after implantation. Averaged out waveforms. Units: ms and µV. Colors show stimulation in different limbs.

Conclusions

- Successful fabrication and testing of thin film neural implants for measuring and stimulating in brain cavities

- Ongoing work on:
  - Further insulation lifetime improvement
  - Coating with growth factor releasing resorbable materials (study with control group going on now)

Acknowledgements

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